CoBOP Coral Reefs: Optical Closure of a Coral Reef Submarine Light Field

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LONG TERM GOALS

As a result of our success with ocean color studies in blue, oceanic waters, we believe we are in a good position to use many of the same methods for the study of coastal ocean processes. Optically active substances are more diverse in coastal waters compared to offshore. We want to know: 1) what are the processes that are responsible for changes in optical properties, 2) what are the energy sources that bring about these changes and 3) what is the magnitude and variability of the optical signals. In optically shallow waters, the effects of bottom reflectance also act to change the wavelength characteristics of the in-water optics. By achieving optical closure, above water optical remote sensing systems can be developed that will allow comparison of coastal ecosystems in time and space.

OBJECTIVES

We want to predict the relative importance of substances that influence the inherent and apparent optical properties by direct measurements of the submarine light field. The advective features of the water column believed to be of major importance to optical variability are tidal flow, winds and other barotrophic effects. In turn, this variability modulates all other optical fields including benthic and remote sensing reflectance, with water depth as an important variable. Changes in benthic habitat type and benthic diversity are equally important. We wish to quantify the dominant species of the habitat by videography and assess the influence of bulk *in situ* benthic reflectance as a function of habitat and water depth on remote sensing reflectance.

APPROACH

An Aanderaa Model DCM12 upward looking ADCP/tide gauge/wave analyzer with near-bottom optical instruments attached to the frame is used to assess the contribution of tidal and wind induced flow to increased optical variability in the water column. The ADCP unit operates at 606.7 Hz and is designed for deployment in 3-50m of water. Three to five depth cells above the null (bottom) cell are monitored for current speed and direction. State of tide (water level) and significant wave height are measured using a quartz pressure cell and determined as $H^{1/3}$. Data are logged internally as three minute averages. The optical package consists of a Sea-Bird Electronics Seacat 19 CTD, WETLabs miniature WETStar chlorophyll fluorometer and WETLabs CStar single channel transmissometer

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(25cm path, 488nm). Sample water is pumped through the system to ensure sample turnover and reduce fowling, the optical windows are cleaned daily by divers. Water column optical properties are monitored daily at several sites by profiling a WETLabs AC-9 and CTD package and by Niskin bottle samples for spectral particulate and dissolved absorption, chlorophyll and total suspended solids concentrations.

The optical effect of increasing water depth is studied by measuring benthic reflectance across a depth gradient. Spectral reflectance measurements are performed *in situ* using an Analytical Spectral Devices Field Spec spectrometer with 512 channels between 340 and 1080nm. *In situ* measurements are obtained by a diver placing a cosine collector at the end of a 10m fiber optic next to a specimen on the bottom and measuring the reflectance under natural light referenced to a standard plaque measurement (Spectralon 99% standard) obtained under the same light conditions. Digital color videography is used for species identification and percent cover assessment in order to visually relate benthic habitat types to spectral signatures. Seven transects have been measured in the Florida Keys and five at Lee Stocking Island in the Bahamas.

RESULTS

Water column optical variability was extremely low in the waters offshore Lee Stocking Island during the 1999 field effort. Wind events were largely responsible for changes compared to tidal effects at a site south of N. Perry Reef in 20m of water. Clear Exuma Sound water ($c488 < 0.1\ m^{-1}$) was advected onto the shelf during periods of westerly winds resulting in extremely high water transparency and low variability. These conditions are ideal for the study of optical closure where concerns about spatial and temporal variability can severely limit the utility of datasets.

In terms of the ecological implications of water clarity, the waters off Lee Stocking Island have much higher transparency than the Florida Keys. This difference is attributable to anthropogenic inputs which act to increase water column particulate and dissolved loads and primary productivity. The result is decreased transparency and decreased percent of hard coral cover. One surprise we have found is that percent cover of hard corals in the Florida Keys at pristine sites is low at about 20% (at Key West corals comprise only 3% cover). Lee Stocking Island sites come in at about 25% hard coral cover which is low given the clear waters. The curve which relates water transparency to percent coral cover is extremely steep with large differences in coral cover occuring over small changes in water transparency. Healthy coral communities require clear water.

IMPACT/APPLICATIONS

Analyzing the relationship between water column attenuation and percent coral cover suggests that one of the major factors affecting the decline of coral reefs is change in water transparency driven by anthropogenic rather than natural processes. Corals are known to thrive in clear oceanic waters where optical variability is low. This results in a marked sensitivity to light indicated by low photosynthesis to respiration (P:R) ratios for the algal symbiont. Hence, rather small changes in water transparency are manifested as large changes in coral growth. It is too early to say whether Lee Stocking Island will be impacted in the way Florida Keys reefs have declined. Reefs off Florida are threatened by decreased transparency due to anthropogenic nutrient sources which result in algal overgrowth and inevitable reef destruction. Whatever the effect, optical remote sensing techniques can be used to study and monitor reef ecosystems where small changes in optical properties can impart large changes in community structure and diversity.

TRANSITIONS

Water column optical data have been distributed to various members of the project on request. We have not submitted data to the CoBOP database at the time of this reporting as we are awaiting final formats to be distributed in order to minimize redundancy.

RELATED PROJECTS

This project has benefitted from direct interaction with the FILLS group led by Dr. Mike Strand at the Coastal System Station, Panama City, FL, during joint field efforts off Lee Stocking Island. We are also members on the CoBOP subcommittee for remote sensing and collaborate with Dr. Ken Carder at USF and Dr. Curt Davis at NRL. Coral studies and benthic reflectance measurements are made in cooperation with Dr. Mike Lesser of UNH and Dr. Charles Mazel at Psicorp, Inc., respectively.

PUBLICATIONS

Lesser, M.P., C.H. Mazel, D.A. Phinney and C.S. Yentsch. Photoadaptive response of hematypic corals. In press: Limnology and Oceanography.

Yentsch, C.S. Coral reefs and upwelling. In press: Limnology and Oceanography as comment.

Zaitzeff, J.,E.J. D'sa, C.S. Yentsch and J. Miller. Rapid assessment of salinity contrasts in Florida Bay and linkages to biooptical characteristics. In press: Limnology and Oceanography Symposium volume on Linkages Between Ecosystems - the South Florida Hydroscape.

D'sa, E.J., R.G. Stewart, A. Vodacek, N.V. Blough and D.A. Phinney. 1999.Determining optical absorption of colored dissolved organic matter in seawater with a capillary waveguide. Limnol. Oceanogr., 44: 1142-1148.

PATENTS

Christian Sieracki, Michael Sieracki and Charles Yentsch. Device and method for studying particles in a fluid. Patent application submitted October 21, 1999.